Infrastructure for Sustainable Growth: A Demand Projection Exercise for India

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Running Title: ***Infrastructure Demand Projection for India***

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Abstract

Critical precondition for attaining growth and sustainable development is availability of a host of infrastructural facilities in adequate quantity and of reliable quality. The association between the latter and growth is well documented and a large number of theoretical propositions conclude that the association is quite strong and runs from the former to the latter. India, on attaining independence, accorded highest importance to the development of infrastructural facilities and lion's share of the plan outlays were on this sector. This resulted in a remarkable growth in such facilities. But the recent spurt in actual and target growth rates has been associated with substantial shortages in the physical availability of infrastructural facilities. To achieve and sustain the growth targets such shortages must be removed. This should start with determining the likely demand for these facilities both at current levels of economic intensity and at levels corresponding to desired growth rates. In this paper we seek to forecast the demand for selected infrastructural facilities for India over the next decade and a half so that we have an idea regarding the magnitude of the task facing the economy. In addition to projecting physical quantum of demand for those facilities, we also attempt at indicating the financial implications of realising those levels. The projected demand is substantially larger than the present availability and the task becomes harder as not only population will rise in future but the per capita demand would also increase. The Capacity Addition required would call in for huge investment amounting to a Capital outlay of 6-6.2 per cent of GDP for the five selected sectors only. One possible way to dent into this awesome job is to use a dual strategy. Along with heavy investment in creation of new physical stock of infrastructural facilities, one must also aim at improving the utilization rate and operational efficiency of existing stock.

Keywords: Infrastructure; Demand Projection; Sustainable Growth;
JEL Classification: **C21; C33; C53; H54; O21.**

I. Introduction

High growth and sustainable development are the principal objectives of developing countries in the present world. In a globalised framework, this requires efficiency in production and availability of resources – both material and services – so that output can be augmented up to the fullest potential and prices are competitive. A major precondition for attaining those goals is availability of a host of infrastructural facilities in adequate quantity and of reliable quality. The association between the latter and growth is well documented and a large number of theoretical propositions conclude that the association is quite strong and runs from the former to the latter [e.g. Hirschman (1958), Rostow (1960), Nurkse (1953), Rosenstein-Rodan (1943) and Hansen (1965)]. In the recent decade, this issue has attracted attention worldwide, and the association between Infrastructure Availability and Development/Growth has been widely explored. Some studies, mostly on the developing economies, conclude that the impact of infrastructure on economic development is positive and substantial [e.g. Looney (1981), Antle (1983), da Silva Costa (1987), Aschauer (1989), Garcia-Mila (1992), Easterly (1993), Canning (1993), and others]. On the other hand, studies involving developed nations conclude that though there is positive influence of infrastructure on economic growth, the magnitude is not substantial [e.g. Hulten (1984), Evans (1994), Holtz-Eakin (1994), Crihfield (1995), Conrad (1997), and others]. Following theoretical understanding and based on whatever empirical evidences available, India, on attaining independence, accorded highest importance to the development of infrastructural facilities. The successive plans were formulated on such lines that the infrastructural sectors claimed the lion's share of the plan outlays and actual expenditures. If all the ten plans along with the annual plans are considered together, it is observed that of the Total Allocated Spending of Rs. 33954 Billion, the infrastructural sectors claimed Rs. 22452 Billion, i.e. more than 66% of the total allocation. It has been because of such paramount importance being attached to the development of the infrastructure in our economic planning that long strides have been made in the physical availability of such facilities in India. There has been a remarkable growth in the absolute level of such facilities, as well as in the level relative to the size of the nation and population, i.e. in standardized forms. However, the progress is not that much commendable if we compare it to global standards. In fact India lags behind not only the developed nations, but also from the average of the middle-income countries, to which group it belongs. Against this backdrop, the Structural Adjustment Programme (SAP) introduced in India in a systematic way in early nineties demarcated the role of the State and that of the private entrepreneurs. In the transformed regime, the State is to play the role of a facilitator of activities, while the expansionary effort is to be taken up mainly by the private players. However, this requires that the basic infrastructural services be in place in terms of quality, reliability, and quantity. Only when the transport, communication, education, health, financial and other skeletonsupport system are working properly and smoothly that investors will be attracted to a region. As a result, availability of infrastructural services becomes a significant determinant of volume of capital inflow and magnitude of economic activities in a particular region.

Many researchers have commented on this crucial interlinkage and tried to estimate the contribution of infrastructure on national or regional development in India [e.g. Shah (1970), Dasgupta (1971), Pal (1975), Shri Prakash (1977), Gulati (1977), Gayithri (1997), Tewari (1984), Amin (1990), Dadibhavi (1991), Arunkumar (1993), Ghosh (1998), Majumder (2005)]. Surprisingly, there are hardly any studies that attempt to look into the future needs of infrastructure in India. However, no studies on infrastructure can be complete unless there is a vision before the nation – a vision of what it wants to be in near future, what are needed to achieve those dreams, and the possible roadblocks. This analysis is all the more necessary as constraints, shortages, bottlenecks, or imbalances in either quantity, quality, or accessibility of infrastructural facilities will invariably lead to deficiency in the overall development performance. Therefore, any policy-making related to infrastructure should start with determining the necessities – the likely demand for these facilities both at current levels of economic intensity and at levels corresponding to desired growth rates. In this paper we seek to forecast the demand for selected infrastructural facilities for India over the next decade and a half so that we have an idea regarding the magnitude of the task facing the economy. We have selected Roads, Railways, Power, Schools & Colleges, and Hospitals for this scenario analysis. It is to be noted that this relates to stocks of these facilities and *not* flow of the services emanating from them or their utilisation rates. In addition to projecting physical quantum of demand for those facilities, we also attempt at indicating the financial implications of realising those levels.

Table 1

Indicators of Infrastructure Stock in India 2005

State	**Road Length**	**Railway Length**	**Power Gen Cap**	**Schools**	**Colleges**	**Hospital/ Dispensary**
	KM per Lakh Pop	KM per Th SqKm	MW per Capita	per ‘0000 Pop	per ‘0000 Pop	per Mill Pop
Andhra Pr	253	18	107	14	0.14	40
Bihar	95	30	72	8	0.07	5
Gujarat	208	28	167	9	0.07	173
Haryana	155	35	143	7	0.12	12
Himachal Pr	500	5	116	23	0.10	31
Karnataka	303	17	144	13	0.20	18
Kerala	488	25	164	6	0.08	38
Madhya Pr	228	14	104	10	0.08	-2
Maharashtra	233	18	175	9	0.13	81
Orissa	489	14	112	17	0.10	34
Punjab	293	41	176	10	0.17	59
Rajasthan	216	17	90	8	0.07	5
Tamilnadu	367	30	129	11	0.09	13

Uttar Pr	118	30	47	5	0.04	14
W Bengal	98	43	93	11	0.08	6
Delhi	78	112	402	3	0.08	110
India	216	21	97	8	0.08	34

Source: Statistical Abstract, GOI, Various Years, from www.mospi.nic.in.
Note: Power Gen Cap is Installed Power Generating Capacity.

II. Current Endowments of Infrastructure Stock

The endowments of infrastructural stocks in India have already been outlined earlier in Chapter Four. To refresh our memories, we can look at Table 1, which provides stock of the selected infrastructural facilities in India in 2005, normalised with respect to population or area, as the case may be.[1] Substantial variation in stock across different regions is evident.

Table 2

Indicators of Infrastructure - Global Comparisons

Country	GNP Per Capita	Area	Population	Installed Power Capacity	Power generated	Telephone Main Lines	Railway	Total Road Length	Surfaced Road Length	Surfaced Road Length	Density on Roads	NIA as % of total cropped area	Access to safe drinking water	Physicians	Primary Teachers
	US $	1000 sq km	Million	KW per million population	KWH per million population	per thousand population	KM per 1000 sq km area			% of total road length	KM per Million Population		% of population	per million population	per 1000 population
Bangladesh	220	144	114.4	22.03	22.03	2113	19	94	55	58.5	118.3	20.4	78	NA	16
India	**310**	**3288**	**883.6**	**86.01**	**84.54**	**5743**	**18**	**599**	**291**	**48.6**	**2229.0**	**13.8**	**73**	**406**	**17**
Kenya	310	580	25.7	28.13	28.13	6811	4	105	21	20.0	2369.6	0.1	49	98	32
Pakistan	420	796	119.3	78.35	76.59	7069	11	212	64	30.2	1414.5	21.3	55	340	24
China	470	9561	1162.2	118.65	118.65	5894	5	107	21	19.6	880.3	4.9	72		45
Low income	***390***	***38929***	***3191.3***	***NA***	***53***	***6***	***NA***	***NA***	***NA***	***NA***	***396.0***	***NA***	***62***	***89***	***26***
Indonesia	670	1905	184.3	70.10	62.29	5785	3	149	65	43.6	1540.1	4.3	34	142	43
Philippines	770	300	64.3	109.19	106.83	9487	1	535	77	14.4	2496.1	5.2	81	123	30
Middle income	***2490***	***62470***	***1418.7***	***NA***	***373***	***81***	***NA***	***NA***	***NA***	***NA***	***1335.0***	***NA***	***74***	***495***	***40***
Australia	17260	7713	17.5	2057.83	2101.83	444965	4	105	37	35.2	46278.0	0.2	100	NA	59
UK	17790	245	57.8	1263.20	1264	438893	67	1455	1455	100.0	6167.4	0.7	100	NA	50
Canada	20710	9976	27.4	3800.73	3800.73	558241	8	82	28	34.1	29855.2	0.1	100	2222	67
USA	23240	9373	255.4	2871.31	3036.01	533817	22	666	387	58.1	24441.7	2	100	2381	NA
Japan	28190	378	124.5	1564.10	1564.36	437975	53	2962	2040	68.9	8993.1	7.5	96	1639	48
High income	***22160***	***31709***	***828.1***	***NA***	***2100***	***442***	***NA***	***NA***	***NA***	***NA***	***10106.0***	***NA***	***96***	***2381***	***59***

Source: WDR (2002), and Economic Survey, Govt. of India - Various Years

The relative position of India compared to certain other country groups have been depicted in Table 2, showing that we are ahead among the Low Income countries (to which group we belong) in terms of Rail Density alone. In terms of Per Capita stocks of Power Generation, Road length (Road freedom), Schools, and Hospitals, we are not only far behind the High & Middle Income economies and the developed countries, we are lagging behind the average level for Low Income Countries also. Thus there is scope for improvement even when present demands are considered. Against this existing shortages, the need to estimate future demands becomes all the more important since any imbalance in the quantity or location of the facilities will create bottlenecks for the entire economy and jeopardise the growth process.

III. Modelling Demand

1. <u>Methodology</u>

Modelling demand for infrastructure, or for that matter any other *'input'* for desired developmental goals (or *'output'*) is tricky. One can simply calculate current or historical input-output ratios and use it in conjunction with projected or desired *output level* (GDP, PCI, etc.) to get projected demand for the *inputs*, infrastructure in this case. While being straightforward and easy, this methodology is unacceptable for various reasons, most important of which is that the input-output ratios are themselves variable. This is more so for the infrastructural variables that are characterised by economies of scale, long gestation period, and indivisibilities, resulting in rapid changes in their impact quotient on development following changes in their quantum. Conversely, the infrastructure required per unit of GDP or PCI would vary with changes in GDP or PCI or other instrumental variables. Thus their modelling has to accommodate not only changing levels of target variables, but also changes in the coefficients associated with those variables in determining infrastructure demand.[2]

Looking from a different side, changes in the income level changes people's demand for different facilities like transport, power, education, and health. Thus, per capita demand for these facilities is surely function of per capita income. In addition, most of these facilities are characterised by networking and indivisibilities, so that their per capita demand reduces with a rise in population density. The same is true for Urbanisation factor also as many of the facilities are urban-centric. Thus our basic model should be of the form:

$$D_{ij} = f\,[PCI_j, PD_j, U_j],$$

where D_{ij} is Demand for i^{th} infrastructural facility in the j^{th} region; PCI_j, PD_j, U_j are Per Capita Income, Population Density, and Urbanisation Index in the j^{th} region.

We now expand this basic model as follows. Demand for power is divided into three parts – Industrial Demand, Agricultural Demand, and Other Demand, and modelled separately. Moreover, Infrastructural demand would also depend on the structural transformation of the economy. Traditionally, the share of GDP coming from Tertiary sector is taken as an index of structural transformation of an economy. We include this (Ter_%) as an explanatory variable in our model. In addition, specific infrastructural demands are thought to be affected by sector-specific variables. For example, Road requirement would depend on the number of vehicles i.e. vehicle-population ratio; Industrial power demand would depend on proportion of GDP coming from Secondary sector (Sec_%); Power demand by agriculture would depend on per capita Gross Cropped Area (GCA_Pop) & Share of agriculture in GDP (Agr_%); Number of schools would depend on the desired school completion rates of children (Comp8); and for the Health sector, reduction in Infant Mortality Rate (IMR) is taken as the sectoral instrumental variable.

Sometimes researchers argue that due to long gestation period and life of infrastructure stocks, lagged values of infrastructure should also be included in the model. But this is a supply side constraint and inclusion of lagged values would make the model a Supply side model. Since we are trying to project demand irrespective of existing or past supply of infrastructure, we do not include it.

We must mention one inherent assumption made herein. Since we are using existing infrastructural stock as infrastructural demand, we are assuming that the demand has been met in all past periods. While this is definitely not true, we can see it as some kind of *'ex post'* value of demand corresponding to the ruling values of instrumental variables (IV) if we accept that the levels of the IVs themselves were determined and constrained by the infrastructure available. Therefore, once the IV, say GDP, has been determined, a one-to-one correspondence between them and stock of infrastructure can be viewed backwards also, i.e. the level of infrastructure would then be viewed as the stock demanded to achieve the resultant level of GDP etc. This is restrictive but quite logical.

Table 3
Model Description - Infrastructure as Dependent on Instrumental Variables

Dependent Variable	Unit	Instrumental Variables
Road Length	*KM per Lakh Pop*	**PCI, Vhcl_Pop Ratio, TER_%, Density, Urbanisation**
RailwayLength	*KM per SqKm Area*	**PCI, TER_%, Density, Urbanisation**
Industrial Power	*KWH per Person*	**PCI, SEC_%, TER_%, Density, Urbanisation**
AgroPower	*KWH per Person*	**PCI, AGR_%, TER_%, Density, GCA_Pop Ratio**
OtherPower	*KWH per Person*	**PCI, TER_%, Density, Urbanisation**
Schools	*per 10000 Pop*	**PCI, TER_%, Density, Urbanisation, Completed 8**
Colleges	*per 10000 Pop*	**PCI, TER_%, Density, Urbanisation**
Hospital	*per Million Pop*	**PCI, TER_%, Density, Urbanisation, IMR**

The variables are depicted in the natural log form and the complete model is described in Table 3. The IVs of our model then are Per Capita Income (and therefore GDP and

Population); Shares in GDP of Agricultural, Industrial & Tertiary sectors; Population Density; Urbanisation Index; GCA-Population ratio; Proportion of children completing Class VIII; Infant Mortality Rate; and, Vehicle-Population ratio. The levels of these IVs in 2005 are given in Table 4.

Table 4
Instrumental Indicators in India 2001

State	PCI RS	Agr_%	Sec_%	Ter_%	Density Per Sq Km	Urb %	GCA_Pop Hectare Per person	Comp8 %	IMR Per '000	Vehicle Per '000 Person
Andhra Pr	2561	30	24	45	274	30	0.175	40.0	65.0	59.4
Bihar	1240	30	34	35	605	17	0.097	20.0	62.0	19.4
Gujarat	3800	12	51	35	251	37	0.230	58.0	62.0	119.0
Haryana	4419	34	27	38	462	30	0.286	69.0	67.0	97.2
Himachal Pr	3160	21	33	39	113	12	0.147	86.0	64.0	37.6
Karnataka	3471	30	29	41	272	37	0.237	57.0	57.0	65.9
Kerala	2765	25	33	39	838	21	0.096	100.0	14.0	69.2
Madhya Pr	1964	32	29	38	180	24	0.311	37.0	87.0	50.9
Maharashtra	5185	14	40	46	306	44	0.226	74.0	48.0	77.1
Orissa	1767	26	23	46	232	13	0.221	41.0	96.0	33.4
Punjab	4877	41	33	27	470	35	0.320	56.0	52.0	128.0
Rajasthan	2310	34	28	38	161	25	0.364	38.0	79.0	56.9
Tamilnadu	3403	17	38	45	475	44	0.102	100.0	51.0	109.7
Uttar Pr	1896	37	22	39	580	27	0.150	26.0	83.0	33.1
W Bengal	3518	24	31	43	894	31	0.111	37.0	51.0	26.7
Delhi	7837	1	35	64	9185	97	0.004	43.0	30.0	272.6
India	3172	23	31	44	330	30	0.197	46.0	68.0	59.4

Note: PCI is at Constant 1980-81 prices.
Source: Same as Table 10.01.

1. Empirical Estimation

Once we have set the models, we proceed to estimate them empirically. We use the time series data for India and the states for the period 1971-2001 which we have used earlier. The objective is to estimate the coefficients of the IVs in determining per capita infrastructural demand. To accommodate differences across regions in the intensity of infrastructure use, technologies, tastes and preferences, etc. we pool the data set and use Fixed Effects Panel Data Technique for estimation.

It is to be noted that earlier we had observed most of the infrastructural variables to be cointegrated with the developmental variables. In the presence of cointegration, one could have used plain OLS method of estimation also, but we prefer the Fixed Effects Panel Data method as the estimates obtained from this method is consistent even in absence of cointegration.

To check for structural breaks in the associations, we had divided the study period into three decades – 1971-80, 1981-90, 1991-2001, and used Chow test for detection. Except agricultural power demand, none of the other variables are suffering from structural breaks and hence the models were estimated using the whole data set. Only for agricultural power demand a structural break was observed, the 1981-90 and 1991-2001 results being different from that of the first decade, but similar among themselves. Therefore, we estimate this demand function using 1981-2001 data to obtain the most recent estimates.

Table 5

Infrastructure as Dependent on Instrumental Variables – Panel Data Results

Dep. Variable	Road Length	Railway Length	Industrial Power	Agro Power	Other Power	Schools	Colleges	Hospital
	KM per Lakh	KM per SqKm		KWH per Person		per '0000 Pop	per '0000 Pop	per Mill Pop
PCNSDP	0.056**	0.016	0.749**		1.008**	0.426	0.264	0.101
Vhcl_Pop Ratio	0.214							
AGR_%				-0.337				
SEC_%	0.226**		0.887**					
TER_%	0.218**	0.099**			1.141**			
Density	-0.974				0.701**	-0.944	-0.636	-0.529**
Urbanisation	-0.117				0.378	0.112	-0.163	-0.270
GCA_Pop Ratio				0.488*				
Completed 8						0.142**		
IMR								-0.720**
Fixed Effects								
Andhra Pr	7.58	2.40	-4.06	6.95	-12.85	3.56	0.19	8.72
Bihar	7.73	2.97	-4.19	4.98	-13.29	4.41	0.20	8.02
Gujarat	7.12	2.88	-3.92	7.06	-12.84	2.91	-0.44	9.94
Haryana	7.56	3.05	-4.30	7.15	-13.09	3.11	0.33	8.54
Himachal Pr	7.38	1.08	-4.63	2.62	-11.45	3.08	-0.80	8.52
Karnataka	7.78	2.30	-3.89	6.82	-12.91	3.24	0.51	8.78
Kerala	9.24	2.75	-4.23	4.43	-13.20	3.58	0.37	9.31
Madhya Pr	7.15	2.14	-3.92	6.25	-11.98	3.19	-0.49	7.94
Maharashtra	7.55	2.37	-4.21	6.56	-12.92	2.96	0.20	9.86
Orissa	8.21	2.09	-3.72	4.02	-12.24	3.98	-0.15	8.50
Punjab	8.09	3.27	-3.61	7.46	-13.13	3.50	0.59	9.93
Rajasthan	6.97	2.35	-4.23	6.12	-12.34	2.74	-0.74	8.23
Tamilnadu	8.28	2.92	-4.13	6.81	-13.37	3.46	0.10	8.65
Uttar Pr	7.87	2.94	-4.48	6.11	-13.35	3.74	-0.40	8.83
W Bengal	7.93	3.26	-4.57	4.66	-13.63	4.25	0.38	8.31
Delhi	9.73	4.18	-4.63	4.16	-15.20	5.15	1.94	11.46
India	7.64	2.53	-4.24	6.33	-12.92	3.18	-0.23	9.19
No of Obs.	527	527	527	351	527	527	527	527
Adj R Sq	0.73	0.98	0.73	0.97	0.75	0.28	0.16	0.73

Note: * and ** refers to significance at 5% & 1% levels respectively. Coefficients with significance level more than 10% are not reported.

Source: Author's Calculation

Once estimated, we have tested for goodness of fit and the prospects of dropping/ adding variables. Using F-tests and Log Likelihood ratios, we have tried to eliminate IVs that have limited/ insignificant explanatory power and have retained only those that matter, re-estimating the final models. Thus, Data-mining was consciously adopted to improve the predictive power of the projected demand functions.

The estimation results are given in Table 5.

A few general comments may be made regarding the estimation results. It is observed that PCI and Share of Tertiary sector in GDP have significantly positive coefficients all throughout, confirming our a priori notion regarding increasing infrastructural demand per capita along with a rise in income level and structural transformation of the economy. Network properties and indivisibilities leading to lowering of per capita requirement with increase in population density is found to be true for Roads, Schools & Colleges, and Hospitals. However, Power demand by Non-industrial – Non-agricultural sector is significantly positively associated with both density and urbanisation, indicating perhaps the high per capita power demand in densely populated urban areas due to intense economic activities and heavy use of appliances. Relation of Colleges and Hospitals with Urbanisation is negative, indicating that proliferation of higher educational and medical institutions has not kept pace with urbanisation and per capita stocks of these facilities have come down. Moreover it also indicates that rural areas are being sidetracked during establishment of these institutes.

The model estimates are quite dependable and robust as indicated by the Adjusted R^2 values for Roads, Railways, Power, and Hospitals. For Schools & Colleges however, the estimates are moderately dependable.

Table 6
Projection of Instrumental Indicators 2007-2020

Year	PCNSDP RS	Agr%	Sec%	Ter%	Density Per Sq Km	Urb %	GCA_Pop Hectare Per person	Comp8 %	IMR Per '000	Vehicle[a] Per '000 Person
Scenario I: Instrumental Indicators Growing at Long Run Trend Rate										
2007	3946	19	28	52	378	28	0.19	62	61	57.8
2012	4612	16	26	58	418	27	0.19	77	57	88.1
2020	5919	13	24	70	489	26	0.18	100	51	156.9
Scenario II: Instrumental Indicators Growing at Rates matching with Vision 2020 Targets										
2007[b]	4590	16	33	50	366	30	0.18	70	60	57.8
2012	6524	11	34	54	396	32	0.16	85	44	88.1
2020	11449	7	35	61	450	36	0.14	100	27	156.9

Note: a – Growth in Vehicles are imputed at Long Run Trend only as Vision 2020 is silent on this.
b - 2007 figures are as per Tenth Plan Mid Term Appraisal Report.
Source: Author's Calculation

IV. Forecasting Demand: Projection into Future

We thus have estimated demand function of per capita infrastructure stocks and obtained consistent estimates of coefficients associated with the instrumental variables. Using these results we can forecast demand for infrastructure in the future for expected/ desired values of the IVs. Thereafter, using population projections we can transform them to physical levels of infrastructural stock required. Such an exercise requires the future levels of the IVs and there are two ways to proceed in this direction. Firstly, we can use trend growth rates of the IVs to predict expected levels of them in future and estimate infrastructure demand. This would be Business As Usual Scenario (BAUS). Secondly, we can use some target growth rates to project levels of IVs in the future and then estimate infrastructure demand. This would be the Best Case Scenario (BCS). We explore both these options herein. For the BAUS we use the trend growth rates in the IVs during 1996-2005 for predicting their values in the future. For the BCS we use the target growth rates as envisaged in the '***Vision 2020'*** document of the Planning Commission of India. The projected values of the IVs at the beginning and the end of the Eleventh 5-Year Plan, i.e. at 2007 & 2012, and at 2020 using both these methods are given in Table 6.

Table 7

Model based projection of Key Infrastructure Ratios in India 2007-2020

Year	Road Length	Railway Length	Industrial Power	Agro Power	Other Power	Schools	Colleges	Hospital
	Km per Lakh Pop	KM per SqKm	KWH per Person			Per '0000 Pop	per '0000 Pop	per Mill Pop
Scenario I: Instrumental Indicators Growing at Long Run Trend Rate – BAUS								
2007	223.6	21.0	137.3	93.0	210.5	7.8	0.10	38
2012	227.5	21.3	145.2	96.2	297.5	7.7	0.09	39
2020	229.0	21.8	158.7	101.6	517.3	7.8	0.10	40
Scenario II: Instrumental Indicators Growing at Rates matching with Vision 2020 Targets – BCS								
2007	238.2	21.0	177.5	98.0	233.1	8.8	0.10	39
2012	249.4	21.3	235.4	108.2	394.5	9.8	0.09	44
2020	262.9	21.7	370.0	126.9	915.9	11.7	0.10	53

Source: Author's Calculation

Base on these values and the estimated coefficients we can obtain normalised values of infrastructural demand for the period 2007-2020. These are given in Table 7. It appears that the normalised values of infrastructure requirement would steadily rise over the next decade and a half. Since the BAUS estimates of the IVs are lower than the BCS estimates of them, the infrastructure requirement would also be lower in BAUS compared to BCS. It is evident that we would require modest advancement in Numbers of Colleges & Hospitals, Railway Track length, and Agricultural Power demand – mostly to keep abreast of the population growth. This is not particularly unexpected as with falling share of Agriculture in GDP, power required by it will rise slowly, and Railway Services, Medical and Higher educational services would be characterised more by intensive use of existing stocks rather than a marked rise in per capita stock. There would however be substantial increase in per capita demand for Industrial Power, Non-industrial – Non-agricultural Power, and Number of Schools.

Using projected population growth, we now arrive at physical targets for the infrastructural facilities during 2007-2020 (Table 8), and the Capacity Addition required over this period (Table 9). Major observations are as follows:

- Power Generation Capacity has to rise more than three-fold;
- Number of Hospitals, Colleges and Schools must increase by 40-80 per cent;
- Road length has to increase by about 40 per cent; and,
- Railway Track length must rise by 5-7 per cent.

Table 8

Projection of Infrastructure Requirement 2007-2020

Year	Road Length	Railway Length	Power Demand				Power Generation	Schools	Colleges	Hospital
			Industry	Agro	Other	Total				
	KM	KM	Million KWH				MW	Nos	Nos	Nos
Scenario I: Instrumental Indicators Growing at Long Run Trend Rate – BAUS										
2007	2597979	64366	158894	107863	244720	511477	152410	927850	10904	44622
2012	2906315	65016	185646	122910	380254	688810	198995	1024252	11850	49259
2020	3434308	67431	238452	152969	775344	1166765	326965	1199758	13538	57699
Scenario II: Instrumental Indicators Growing at Rates matching with Vision 2020 Targets – BCS										
2007	2669367	64328	198934	109808	261236	569978	153125	986863	11112	41679
2012	3026085	65178	285695	131307	478734	895736	218475	1193107	12398	51268
2020	3621829	66562	509814	174797	1261808	1946419	366315	1616422	14772	71323

Source: Author's Calculations based on Tables 10.05 and 10.06.

Table 9

Projected Capacity Addition Requirement during 2007-2020

Year	Road Length	Railway Length	Power Demand				Power[a] Generation	Schools	Colleges	Hospital
			Industry	Agro	Other	Total				
	KM	KM	Million KWH				MW	Nos	Nos	Nos
Scenario I: Instrumental Indicators Growing at Long Run Trend Rate – BAUS										
2007-12	406315	1894	49374	27771	250144	327289	86495	99252	2650	9659
2012-20	527993	2415	52806	30059	395090	477955	127970	175506	1688	8440
2007-20	934308	4309	102180	57830	645234	805244	214465	274758	4338	18099
Scenario II: Instrumental Indicators Growing at Rates matching with Vision 2020 Targets – BCS										
2007-12	526085	2056	140696	34864	352706	528266	105975	268107	3198	11668
2012-20	595744	1384	224119	43490	783074	1050683	147840	423315	2374	20055
2007-20	1121829	3440	370121	77373	1191239	1638732	253815	691422	5572	31723

Note: Power Generation Capacity is calculated assuming PLF and T&D Efficiency to increase by 1 percentage point every year for BAUS. For BCS, PLF is assumed to reach 75% and T&D Efficiency to reach 85% by 2020, increases being evenly distributed over the interim period.

Source: Author's Calculations based on Tables 10.07 and existing endowment of infrastructure in 2005.

Continuing further, we present the State-wise shortages as would be felt during the Eleventh Plan period if current stocks of infrastructure prevail (Table 10). These are therefore reflecting areas of immediate concern. It is observed that the shortages are most acute in the Power sector, followed by the Colleges and Health Facilities. Among the states, situation is particularly poor in West Bengal, Haryana, Rajasthan, and Maharashtra for all the infrastructural sectors, and also in Delhi for Power, Education and Health sectors. The shortages are not as much in Bihar and Uttar Pradesh as many other researchers report – partly because of low demand in those states due to their stagnating economy and partly because the shortfall lies more in quality and reliability of services in these states than in quantity alone.

Table 10

Statewise Projected Shortages during XIth Plan as % of Current Capacity

Year	Road	Railway	Power Generation	Schools	Colleges	Hospital
Andhra Pr	16.9	7.1	40.2	17.2	23.9	15.8
Bihar	20.1	5.0	44.5	1.5	27.0	23.3
Gujarat	16.1	5.2	42.7	9.8	19.7	15.4
Haryana	20.5	4.6	50.2	11.5	22.8	12.9
Himachal Pr	16.6	1.8	54.9	14.7	19.5	14.8
Karnataka	18.5	1.9	46.3	19.6	25.4	36.3
Kerala	11.5	5.6	52.1	5.6	18.9	10.0
Madhya Pr	20.1	8.5	48.5	9.9	18.7	40.0
Maharashtra	17.4	7.1	42.9	10.2	21.8	20.1
Orissa	9.8	1.9	44.6	11.6	17.7	16.6
Punjab	11.8	4.2	38.5	5.6	22.3	16.0
Rajasthan	23.1	7.4	46.9	12.8	21.4	22.5
Tamilnadu	6.6	5.0	40.5	19.0	21.0	14.7
Uttar Pr	13.6	1.9	40.1	20.9	22.8	21.0
W Bengal	18.2	4.1	52.8	15.5	24.4	17.8
Delhi	6.7	2.9	56.0	21.7	26.3	27.7
India	14.0	1.9	43.5	9.7	22.4	19.6

Source: Author's Calculations based on Capacity Addition Requirements till 2012 and existing endowment of infrastructure in 2005.

We have thus been able to chart out the path before us – the task that needs to be completed in the coming years – both to sustain the present growth and also to reach the *Vision 2020* targets.

V. Financial Implications: How Much Investment Do We Need?

The analysis will not be complete unless we provide ballpark figures regarding the financial commitment required to meet the projected demand. But to do so, i.e. to transform physical targets to financial requirement is a tricky business. Costs vary across the breadth of our large country, between projects, and across scales of operation rendering the concept of per unit costs very difficult to pin point in reality. Still various governmental and non-governmental studies as also the budget documents assign per unit costs for setting up of new establishments – roads, railway tracks, power plants, schools, colleges, and hospitals. We scout these studies and arrive at representative Best Practice Average Costs for the infrastructural facilities.[3] The cost per KM of new road is a weighted average of costs for constructing a 4-Lane National Highway, 2-Lane State Highway, and Standard single lane surfaced road and associated maintenance costs. Railway construction costs reflect both construction of new railroad and signalling etc for it. Costs of additional Power Generating Capacity include per Megawatt capacity addition cost and costs of associated Transmission and Distribution Network. Costs for a new school is average of costs per school under DPEP, SSA, and Dept of Secondary Education. Investment required for a new College is taken from Demand for Grants of the Ministry of Human Resource Development. For costs of setting up a new Hospital/ Dispensary, we have used the CEHAT study on Health Budget in India (CEHAT, 2006). They have talked of four types of institutions – Primary Health Centres, Rural Hospitals, Urban Hospitals, and Tertiary Hospitals. Costs for each of them are averaged using suitable weights to reflect the numbers of each required arriving at costs per hospital.

Table 11

Financial Implications of Capacity Addition Requirement during 2007-2020 (Rs Billion)

Year	Road	Railway	Power Generation	Schools	Colleges	Hospital	Total	Avg % of GDP pa
Scenario I: Instrumental Indicators Growing at Long Run Trend Rate – BAUS								
2007-12	17472	76	6920	99	5	386	24958	8.1
2012-20	22704	97	10238	176	3	338	33554	5.0
2007-20	40175	172	17157	275	9	724	58512	6.0
Scenario II: Instrumental Indicators Growing at Rates matching with Vision 2020 Targets – BCS								
2007-12	22622	82	8478	268	6	467	31923	9.6
2012-20	25617	55	11827	423	5	802	38730	4.8
2007-20	48239	138	20305	691	11	1269	70653	6.2

Note: Cost calculations are as explained in text.
Source: Author's Calculations based on Capacity Addition Requirements from Table 10.08 and Cost per unit.

The results are depicted in Table 11. The figures that come out are really stupendous – we need to invest in the five selected areas of Roads, Railways, Power, Education and Health anything between 58500 to 70500 Billion Rupees at current prices over the 2007-2020 period if we are to continue with our present growth rates (at the lower end) or reach the Vision 2020 targets (at the higher end). This translates to an investment of about 6 per cent of our GDP for sustaining trend growth and 6.2 per cent of GDP for achieving desired growth, invested consistently over a period of 14 years! And one must be careful to note that these are ***only*** Capital costs. Costs associated with operation, like Salaries of Staff, Consumables, Administration costs, and costs of inputs linked to functioning and flow of the services have not been included in our estimates – and these latter costs are both quite substantial in magnitude and recurring in nature. Secondly, these services do not operate in airtight compartments - successful running of them require adequate supply from other sectors too. Railway operation needs Power; Power plants and Vehicles need fuel and energy resources; Schools, Colleges and Hospitals need trained manpower and equipment, and so on. Thus the total financial liability for meeting the projected infrastructure demand shall be substantially higher than our figures. If any, these are floor level conservative estimates of onetime capital outlay. Even then, the task appears magnum – both from the physical size and the investment that it calls in for.

VI. Conclusion

We have developed a model to predict future demand for infrastructure, which performs reasonably well for the selected indicators. The projected demand is substantially larger than the present availability and the task becomes harder as not only population will rise in future but the per capita demand would also increase. The Capacity Addition required would call in for huge investment amounting to a Capital outlay of 6-6.2 per cent of GDP for the five selected sectors only. Given that the total plan outlay on the Power, Railways, Roads, Education, and Health sectors during the Eighth and Ninth Plans have been 4.2 per cent and 4.0 per cent respectively; the amount of resource mobilization necessary can be easily anticipated. Moreover, the small increase in private sector financing of infrastructure has not been sufficient to offset the impact of the fall in public sector spending (Briceno-Garmendia et al. 2004). One possible way to dent into this awesome job is to use a dual strategy. Along with heavy investment in creation of new physical stock of infrastructural facilities, one must also aim at improving the utilization rate and operational efficiency of existing stock. Improving T&D efficiency and PLF of power sector, removing bottlenecks and widening of existing roads, increasing enrolment in schools and colleges, increasing beds and medical personnel in hospitals and dispensaries, and improving the carrying strength of railways would mitigate some of the shortages looming large before the nation. At the end of the day the services that flow out of the stock matters, just as the numbers of taps do not matter unless water comes out of them! Improvement in the operational efficiency will be helpful in doing more with the same stock and postpone the crisis point further. Still, the bottom line of the path ahead reads that either the funds are arranged for and invested in the future, or everything goes on as usual only to find that the road has ended before reaching the destination.

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Notes

[1] All facilities except Railway Track Length have been normalised using population. For Railway length we have used area for normalising since spatial density of the network is more important compared to people's accessibility, which is related more to rolling stock of the railways.

[2] This section substantially follows the methodology used by Fay (1999), with appropriate modifications.

[3] The reports and documents used for this purpose are Selected Educational Statistics, GOI (for year 2003-04); Investment Opportunities in Infrastructure, GOI (2006); Report of the Committee on India: Vision 2020, GOI (2002); Changing Health Budgets, CEHAT (2006); Highway Sector Financing in India, World Bank (2004, from www.worldbank.org); Indian Electricity Scenario, GOI (2004); Does India Really have a Power Shortage?, India Infoline (2003, from www.indiacore.com); Towards Faster and More Inclusive Growth: An Approach to the 11th Five Year Plan, GOI (2006); and, Demand for Grants by the respective Ministries of Health, Human Resource Development, Railways, and Surface Transport, available from www.indiabudget.nic.in

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